

# Temperature dependence of antiferromagnetic resonance mode in two-dimensional system $\text{Ni}_5(\text{TeO}_3)_4\text{Br}_2$

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## Abstract

Antiferromagnetic resonance (AFMR) in layered  $\text{Ni}_5(\text{TeO}_3)_4\text{Br}_2$  system with a geometrically frustrated  $\text{Ni}^{2+}$  ( $S = 1$ ) spin arrangement has been investigated. Temperature dependence of the lowest mode resonant field could be described with a simple two sublattice model, considering different magnetic susceptibilities. The AFMR linewidth follows a power law  $T^{2.8}$ , due to the magnon–magnon scattering processes.

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## 1. Introduction

Frustration of magnetic order is encountered in systems where all the pair-wise interactions between the magnetic moments cannot be satisfied at the same time. Typical example is given by antiferromagnetically interacting spins in a triangular lattice.  $\text{Ni}^{2+}$  ( $S = 1$ ) moments in new layered  $\text{Ni}_5(\text{TeO}_3)_4\text{Br}_2$  system are arranged in an interesting double triangular topology [1], where frustration might play an important role. We stress, however, that  $\text{NiO}_6$  octahedra are strongly distorted, resulting in a large single-ion anisotropy, which would act against frustration and favor magnetic ordering. As a consequence, below  $T_N = 29$  K, the  $\text{Ni}_5(\text{TeO}_3)_4\text{Br}_2$  orders antiferromagnetically [1]. Magnetic order can be described with a 10 non-collinear sublattices [2,3]. From neutron diffraction [3], the magnetic moment was determined to be  $\sim 2.15\mu_B/\text{Ni}^{2+}$ , while from the magnetization measurements [4] one would expect  $\mu_{\text{eff}} = g(S(S+1))^{1/2}\mu_B \sim 3.5\mu_B/\text{Ni}^{2+}$ .

We investigated the temperature dependence of antiferromagnetic resonance (AFMR) field and linewidth in order to understand the temperature dependence of sublattice magnetizations.

## 2. Experimental results and discussion

The antiferromagnetic resonance signal measured at  $\nu_L = 324$  GHz and  $\mathbf{B} \parallel a^*$  axis was detected below  $T = 15$  K. With decreasing temperature, the linewidth of the AFMR signal dramatically reduces from  $\Delta B = 1.7$  T at 15 K to 0.075 T at 1.5 K. We also notice a small anomaly at around 5 K (Fig. 1).

Temperature dependence of the AFMR field exhibits even more complex behavior (Fig. 2). With decreasing temperature, the resonance field first increases down to  $T = 8$  K, where it reaches a broad maximum at  $B_{\text{res}} = 5.33$  T. On further cooling, the trend reverses and resonance field is reduced to 5.15 T at  $T = 1.5$  K [3].

The temperature dependence of the resonance signal linewidth (Fig. 1) between 15 and 5 K can be phenomenologically described with a power law  $\Delta B \propto T^\gamma$ ,  $\gamma \sim 2.8(3)$ .

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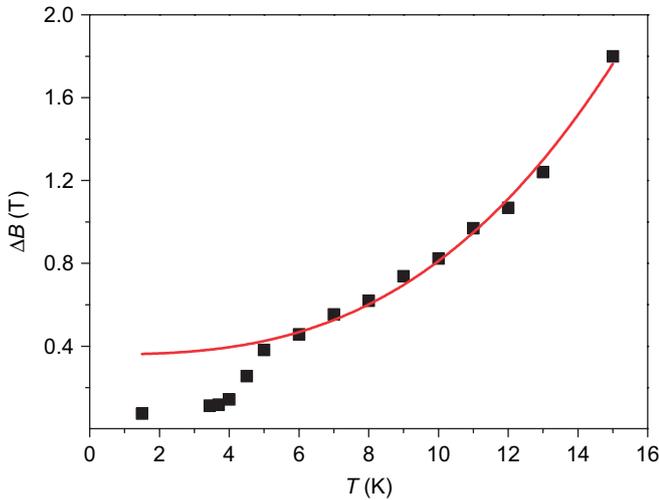


Fig. 1. Temperature dependence of the AFMR linewidth and fit (solid line) to power law  $T^{2.8}$ .

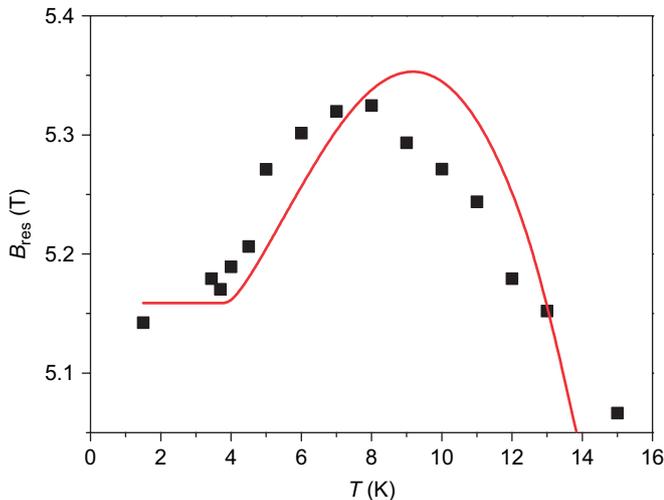


Fig. 2. Temperature dependence of the AFMR field. Solid line presents a fit to the model described in text.

We note at this point that AFMR linewidth is usually determined by four magnon scattering processes leading to  $T^4$  dependence [5,6]. The anomaly at  $T=5$  K as well as the deviation from the  $T^4$  power law thus probably reflect peculiarities in the magnon spectrum in  $\text{Ni}_5(\text{TeO}_3)_4\text{Br}_2$ .

To account for the temperature dependence of the resonance field let us simplify our system with a two sublattice model. Modifying the equation given in Ref. [7] for our problem, for  $\mathbf{B} \parallel a^*$  we find  $B_{\text{res}} = hv/g\mu_B - 2(K_1/\chi_{a^*} + K_2/\chi_b)^{1/2}$ , where  $\chi_a$  and  $\chi_b$  stand for magnetic susceptibilities parallel to  $a^*$  and  $b$  crystal axes and  $K_i$  are corresponding effective anisotropy constants. Using the magnetic susceptibility data from Ref. [3] and the temperature dependence of the resonance field (Fig. 2) we obtained satisfactory fit with  $(2K_1/\chi_{a^*})^{1/2} = 5.1$  T and  $(2K_2/\chi_b)^{1/2} = 6.06$  T. In frequency scale, parameters correspond to 141.1 and 170.4 GHz, respectively. These values should be compared to the zero-field gap  $\sim 450$  GHz and zero-field splitting between the lowest resonant modes  $\sim 90$  GHz [3,8].

### 3. Conclusion

We showed that the temperature dependence of the AFMR field in the  $\text{Ni}_5(\text{TeO}_3)_4\text{Br}_2$  can be in first approximation described with a two sublattice model. The anomalous increase of the linewidth with increasing temperature is likely to be governed by the magnon–magnon scattering processes.

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